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Research and Development Technical Report

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Hi-G Lithium Thionyl Chloride Flat Cells for Artillery/Air Delivered Expendables

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First Quarterly Report for
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20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

Rate capability studies on small prototype cells showed that single anode designs should be adequate for Hi-G rate specifications. Large prototype cells safely delivered 1.6 amps for 6 hours. Design work was begun on seal structures to withstand extreme g forces.

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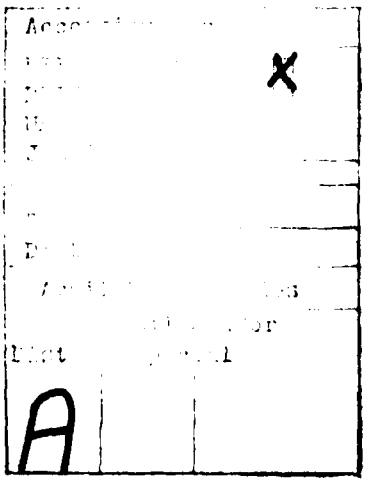


I. Introduction

The main objective of this program is the development of a lithium thionyl chloride flat cell for the titled application. The cell shall be capable of high rate discharge after being subjected to high spin (16,000 rpm) and high shock (17,000 g's).

The starting point for this work was the current state of the art of similar small Altus cells; namely, three disc cells of sizes 0.88 inch diameter, 1.25 inch diameter, and 2.50 inch diameter. These cells exist in several designs depending upon rate capability.

During the first calender quarter a thorough mechanical analysis was made of the ceramic and case designs necessary to withstand extreme stress. Current Altus ceramic to metal seals were purposely stressed, broken, and catalogued by microexaminations for crack patterns.

Further work completed during the first quarter involved the compilation of data available on rate capability and capacity from one and two anode versions of the Altus AL125 and Altus AL125HR cells. These two cells closely approximate the intended Hi-G thickness (.25 inch) but are smaller in circumference. These results provided a base for designing several test groups to be run in early second quarter. A test schedule for Hi-G prototype cells has been proposed.

Early prototype cells were made and discharged. These cells were made from Altus AL450 cell hardware and delivered promising results. Lab work was limited in the first quarter due to Altus moving from Palo Alto to San Jose, and the necessary lab shutdown from 17 November 1980 to 17 January 1981.

II. Hi-G Lithium Thionyl Chloride Flat Cells for Artillery/Air delivered Expendables

The specifications for the Hi-G cell are as follows:

Dimensions: 4.25 inch diameter maximum
0.25 inch height maximum

Voltage: 3.70 volts maximum
2.50 volts minimum operating voltage

Duty Cycle: 1.6 amps for 6 hours
0.100 amps for 50 hours

The cell will be a disc cell design with a stainless steel case and a ceramic to metal seal. Electrode designs will be tested in both single and double anode designs. The test schedule has been proposed as follows:

	Test	No. of Cells
A.	Shock, spin, test for capacity at 20°C	20
B.	Chill cell to -40°C. Shock, spin, test for capacity	5
C.	Heat cell to +63°C. Shock, spin, and test for capacity	5
D.	Store cells at +54°C for 4 weeks. Shock spin, and test for capacity at:	
	20°C	20
	-29°C	20
	-40°C	20
E.	Short circuit: 24 hours at 20°C	5
F.	Reverse voltage: 1.6 amps for 6 hours	5

Shock will be 17,000 g's for 8 milliseconds followed by 16,000 rpm for 2 minutes.

III. Disc Cells 0.25 Inch in Thickness

Experimental

Three types of disc cells of 0.25 inch in thickness have been built and discharged:

A. AL125HR This cell is 1.25 inches in diameter by 0.25 inches in height. The internal construction is that of a single central anode surrounded by two identical cathodes. The combined cathode weight is 0.500 grams. The specified fill is 4.0 grams of 1.6 M $LiAlCl_4$ electrolyte.

Two lots of these cells have averaged 1.10 Ah and 1.13 Ah at discharge rates of 5.7 mA/cm^2. The cells demonstrated identical capacities at a lower rate of 2.9 mA/cm^2.

B. AL125 This cell is 1.25 inches in diameter by 0.25 inches in height. The internal construction consists of two anodes and three cathodes. Total cathode weight was 0.460 grams. The specified fill is 4.0 grams of 1.6 M $LiAlCl_4$ electrolyte.

Cells with this design averaged 1.29 Ah at discharge rates of 2.9 mA/cm^2 and 1.4 mA/cm^2.

C. Hi-G Prototype This cell is the first Altus Hi-G prototype. Two cells were made and discharged at a 1.6 ampere rate, the higher rate of the Hi-G specification. Another cell was made and discharged at a 600 milliamp rate.

Cells were constructed from existing Altus 4.5 inch diameter hardware. Shims were welded inside the can to reduce inner dimensions to 4.33 inches in diameter and 0.150 inches in height. Anode diameter was 3.75 inches by 0.050 inches

in height. Two cathodes were used to enclose a single anode. Total cathode weight was 16 grams. The cells were filled with 50 grams of 1.6 M $LiAlCl_4$ electrolyte.

Test results were:

Cell No.	Load	Capacity to 2.7 Volts	mA/cm^2
HG 1-1	5.0 ohms	10.25 Ah	4.5
HG 1-2	2.0 ohms	8.29 Ah	10.9
HG 1-3	2.0 ohms	9.38 Ah	10.9

Results and Discussion

The voltage-time curves of two AL125HR cells are shown in Figures 1 and 2. These cells delivered 1.22 and 1.11 Ahr to 2.7 volts. The cathode efficiency of these cells was 2.44 Ahr per gram of cathode mix. Earlier experiments at Altus have shown that reduced cathode density improves capacity in thicker cathodes.

The voltage-time curves of an AL125 cell also are shown in Figures 1 and 2. These cells delivered 1.23 and 1.28 A/Hr. to 2.7 volts, with a cathode efficiency of 2.78 Ah/gm cathode mix.

The voltage-time curves of the Hi-G prototypes are shown in Figures 3 and 4. Cathode efficiency was 0.64 Ah/gm, 0.52 Ah/gm, and 0.59 Ah/gm cathode mix.

One of the early goals in this program is to determine whether a single anode or a double anode design is required to meet the Hi-G specifications. The model work on the AL125HR types indicates that a single anode concept is adequate. Improvements from 2.44 Ah/gm to 2.78 Ah/gm do not

appear to justify the added difficulties of two-anode construction. However, the discharge behavior of the Hi-G prototypes varied significantly from the models. The cause of this variance will be sought in the second quarter. It is proposed that the cathode density in the Hi-G prototype could be reduced by 50% and still have an abuse-resistant cathode. This could and should dramatically improve cathode efficiency.

Due to the Altus laboratory shutdown, the Hi-G cells were not examined after discharge. Examination of discharged cells will begin in second quarter.

IV. Abuse Resistant Seals

Tests were run on two different Altus seals as an initial investigation into abuse tolerance. The nature of the test was to weld a short length of tubing to an existing Altus seal, pressurize, and record the pressure necessary to crack the seal.

Two different aspect ratios were tried where aspect ratio equals the ceramic outside diameter divided by the ceramic thickness. Results were as follows:

Aspect:	6.7	Aspect:	2.7
Vent Pressure:	360 psi	Vent Pressure:	508 psi
Pressure Range:	240-510 psi	Pressure Range:	360-560 psi

In all cases the seal cracks in a circular ring near the feed through. No evidence was noted of radial cracks. Mechanical force applied to the feed through also resulted in circular type cracks.

V. Conclusion

During the first quarter the design for the single and double anode Hi-G cell has been proposed and tested in smaller cells. Results have shown that Hi-G capacity and rate can be met by a simple one anode design. Tests on larger cells have shown lower cathode efficiencies. Further work on the prototype was delayed due to facilities relocation.

Design work on a high strength ceramic-to-metal seal and cell case has neared completion. Test seals will be made in smaller can models. A program being conducted to analyze the effects of extreme stresses on existing Altus seals has yielded insight to the potential failure modes of the Hi-G seal.

Planned Investigations

Work planned for the second quarter will begin with a detailed investigation into cathode efficiencies in both smaller and larger cells. Another test program for ceramic strength will be completed in the high strength seal design.

FIGURE 1 : ALTUS 1.25 INCH DIAMETER CELL, 50 Ω LOAD

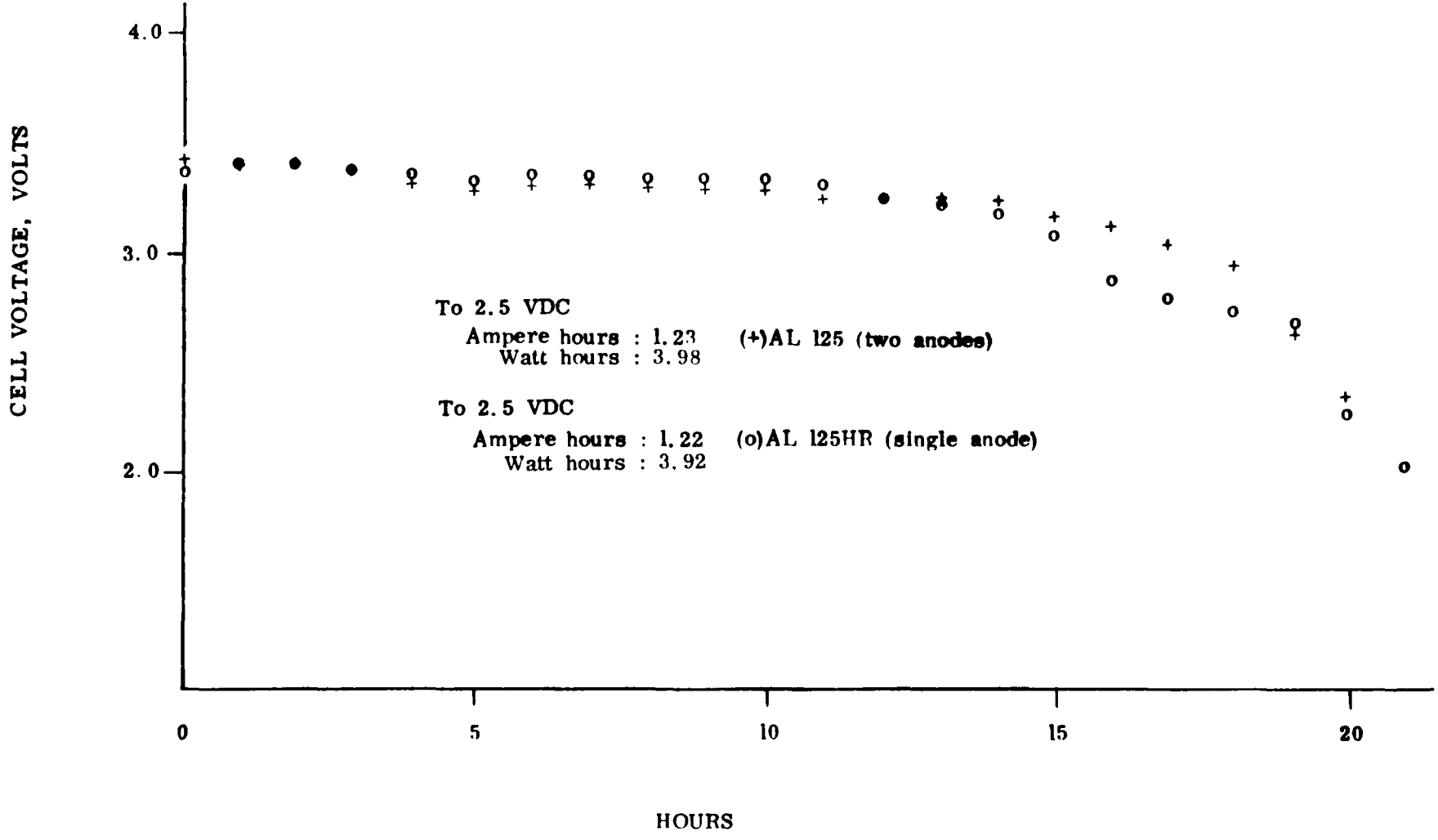


FIGURE 2: ALTUS 1.25 INCH DIAMETER CELL, 100 Ω LOAD

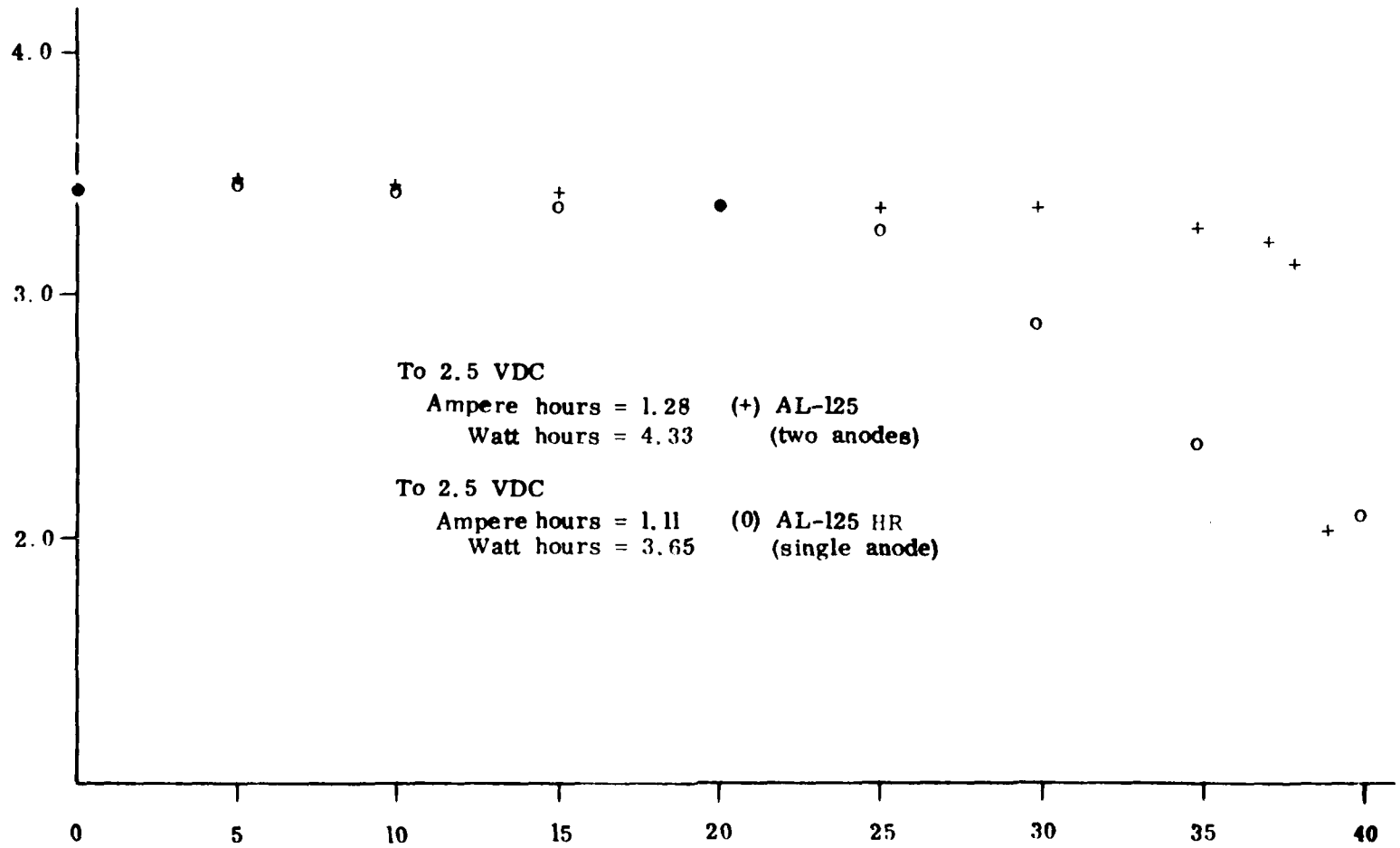


FIGURE 3 : Hi-G PROTOTYPE , 2 Ω LOAD

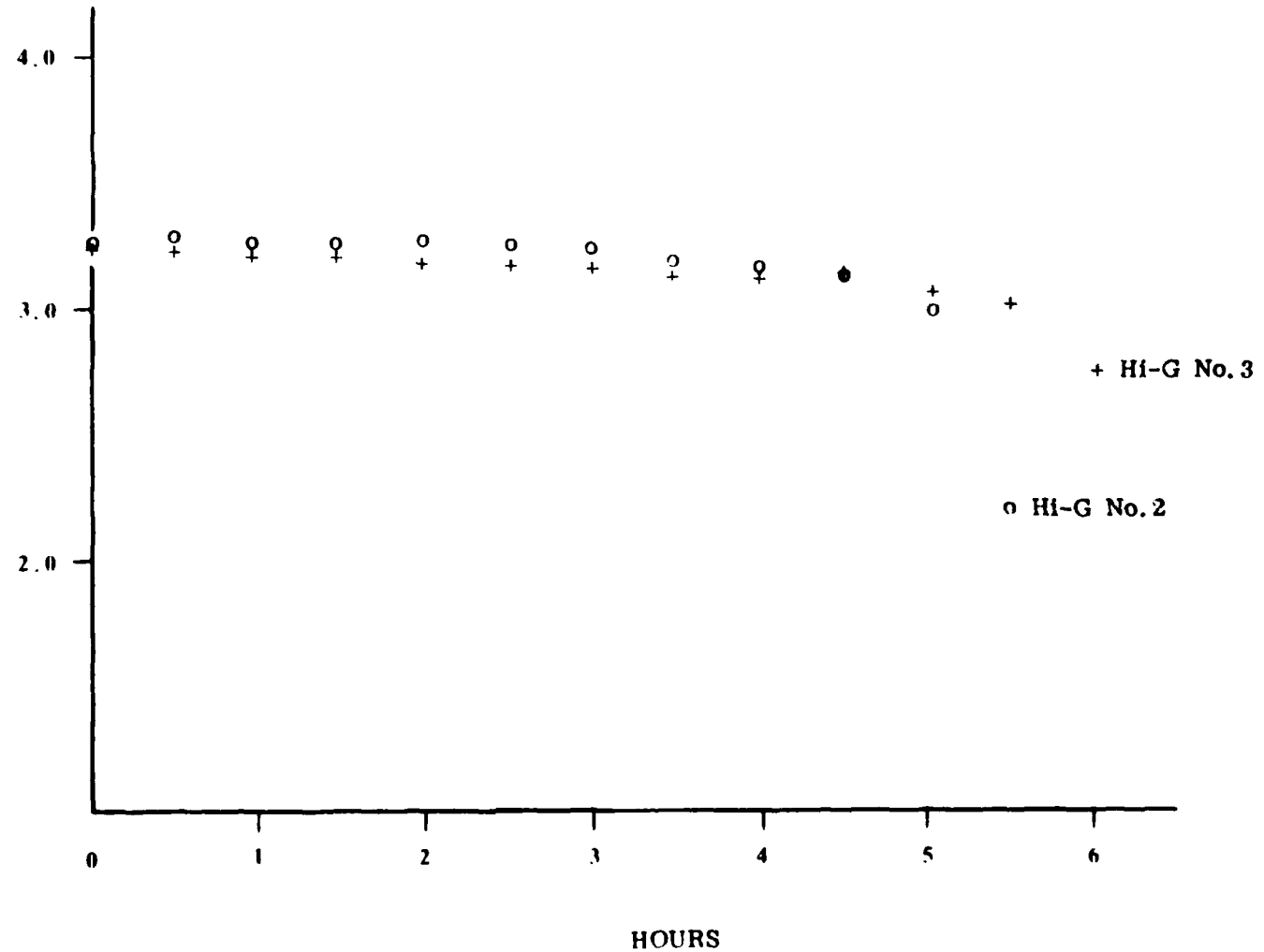
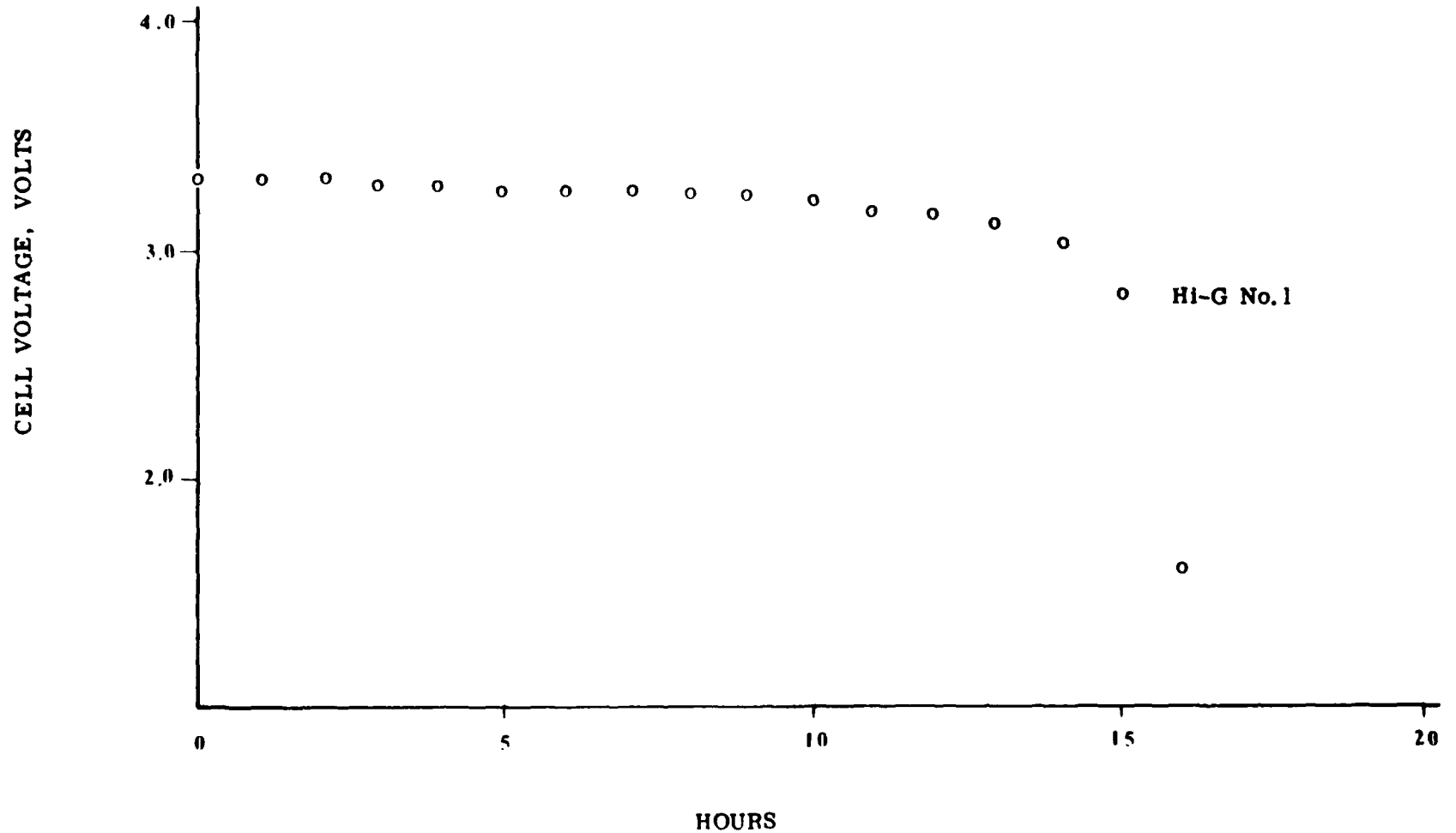


FIGURE 4 : Hi-G PROTOTYPE , 5 Ω LOAD



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